Perhaps this thread may be epitomized by saying that, since the human race has been able to survive and thrive through countless generations with sunlight, sunlight therefore must have in it the necessary elements of radiation to support well-being and efficiency. Just as, although nature originally provided hair on the body and perspiration as protection from cold and heat, man by scientific means and otherwise learned to use clothing, shelter and artificial heating to supplement what nature provided, so, while nature has been very successful, a scientific analysis should enable us to increase the efficiency of society by artificial sunlight. This phase of the presentation should make the book interesting reading to the philosopher, the student of nature and all those who have not a deadened intellectual curiosity.

The opening sentences are most illuminating. "Nature is beneficent—life-giving—but also ruthlessly destructive. Its eternal shower of blessings has not effaced or even dimmed the edict that only the fit shall survive." In the first chaper on "A New Era of Lighting" is shown how man's striving to supply the elements of sunlight in his machine age living has resulted in the development of lamps that supply the requisite character of illumination and the needed ultra-violet light.

In the chapter on the sun's beneficence is given not only an array of historic facts and modern scientific data supporting the theses that sunlight, generally speaking, supports good health, but the argument is made more impressive by a chart showing the relation between the death-rate in the different months of the year and the hours of sunshine corresponding thereto. The chapter on solar radiation is essentially a digest of some of the leading workers in this field. On the basis of these data he concludes that artificial sunlight must be developed more or less independently of natural sunlight, but he does not imply that all the elements known to be useful should not be preserved.

Dr. Luckiesh has supplied the underlying data for designing lighting installations, of artificial sunlight with the various sources and filters available. Although considerable work remains to be done in conserving the requisite ultra-violet component, nevertheless the practical application is already within engineering reach.

Beginning with the fifth chapter, the book consists very largely of the author's data. It is very interesting to note that the carrying out of the problem requires the development of paints for ceilings so that indirect lighting can be used, but where this is not feasible it is always possible to resort to special fixtures, of which many have been designed and several have been built.

F. C. BROWN

MUSEUM OF SCIENCE AND INDUSTRY,
NEW YORK

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW MICRO-MANIPULATOR

Is there a worker with a micro-manipulator who does not wish that his instrument possessed more than merely smooth and exact control in three dimensions; whose impatience has not suggested improvements to facilitate his operations? Suggestions gathered from various laboratories go far to define the ideal manipulator, which should conceivably have the following characteristics:

1. Simple and quick gross adjustments to the microscope, giving a wide range of orientation.

2. Means for immediate return of the point to its operating position after withdrawal of the micromanipulator for the setting or changing of the moist chamber, etc.

3. Grouped controlling handles which permit instant selection and actuation by the fingers of one hand without distraction of attention.

4. Coordination of the motion of each controlling handle with the resultant motion of the operating point, producing, as observed under the microscope, "natural" or expected movement.

5. Complete bilateral symmetry in double instruments through a right- and left-hand arrangement of controls.

6. Identical direction of the motion of each pair of corresponding controls in double instruments to secure identical movements of the respective operating points.

7. Compactness and directness of action, even in combination with a micro-injector, which will permit inclination of the manipulator to an acute angle with the optical axis of the microscope for operations on tissues and organs *in situ* in living animals.

8. Rugged and wearproof moving and bearing parts, so that proper use will not limit the life of the instrument.

An original solution of the mechanical problems involved in micro-operations is offered in the design of a micro-manipulator by the writer, here first publicly described. The special features of this design are covered in applications for patents now pending.

A diagrammatic general view of a double manipulator in relation to a microscope is shown in Fig. 1.

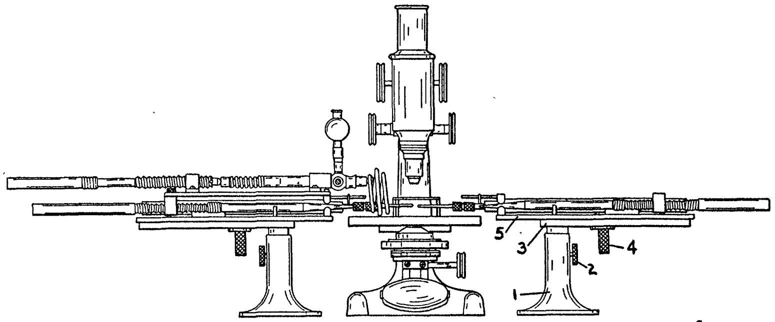

FIG. 1.

To the right-hand instrument is attached a removable micro-injector, applicable to either side. The manipulator is supported on a hollow pedestal 1 which receives the stem of a bracket 3 and holds it at any level by means of the clamp screw 2. The bracket has a broad top with a 4-inch slot through which a screw from the base 5 of the manipulator freely slides, but may be clamped as desired by the nut 4.

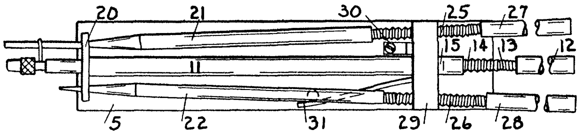

FIG. 2.

The manipulator itself, which rests upon the shelf of the bracket, is best shown in Fig. 2.

The main axis, Fig. 3, is a tubular casing 11 which

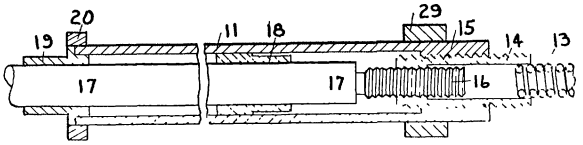

FIG. 3.

encloses the thrust mechanism and guides the thrust rod 17, whose extension carries the operating point. To avoid the serious disadvantages of an extremely fine screw for the control of the thrust motion of the point, a differential screw system has been used (14, 15, 16) which is as direct acting, but permits the use of strong and durable screw threads, *viz.,* 32 and 40 to the inch.

The system is actuated by the handle 12, acting through the spring wire coil 13 upon the hollow screw 14. As the screw in one complete rotation advances one thirty-second of an inch into its nut 15, the screw 16 is drawn back one fortieth of an inch into its nut in the inner end of the screw 14. The advance of the rod 17 and consequently of the operating point is, therefore, their difference, which is 0.00625 inch or 0.156 mm. This is equivalent to one rotation of a single acting screw with 160 threads to the inch (6.4 to the mm) and is amply fine for work under the highest usable power. The actuating handle is small and, therefore, may be rapidly rotated between the thumb and finger for quickly adjusting the operating point.

The rod 17 is supported by close-fitting spring sleeves attached to the guides 18 and 19, which prevent all side motion and thus insure a pure thrust of the operating point. The thrust rod terminates in a tapered stud on which may be slipped corresponding hollow couplings (B. D. subcu needles) carrying operating points.

The motions of the operating point laterally and vertically are produced by cam or wedge action, as shown in Figs. 2 and 4. The end of the tubular axis

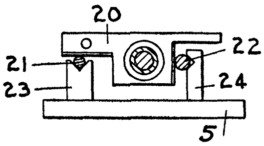

FIG. 4.

11 carries the cross-plate 20 with horizontal and vertical V bearing edges, which are held by appropriate spring action firmly against the cone extensions of rods 21 and 22 lying in their corresponding notches in pins 23 and 24. The cone-ended rods are flexibly attached to the screws 25 and 26, which are threaded through the cross-bar 29.

It is evident that when screw 25 is rotated by its handle 27 to advance rod 21, the cone 21 will push under the horizontal V edge of plate 20 to lift it. It, thereby, raises the operating point. Similar rotation of screw 26 will obviously throw the operating point sidewise.

These two motions, vertical and horizontal, are centered at the cross-bar 29 by the method of its attachment to the base 5, as shown in Figs. 5 and 6. The cross-bar rests on two balls and thus is free to move horizontally and, by tipping, vertically about the horizontal axis connecting the two balls. The center for the horizontal motion lies in the screw pin 30, which

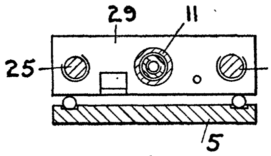

FIG. 5.

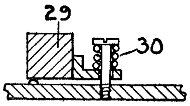

FIG. 6.

passes through a hole in a short offset from the cross-bar 29. This screw pin is surrounded by a coil spring which, pressing strongly on the offset, throws the cross-plate 20 down upon the cone 21 and its notched supporting post 23 and at the same time firmly seats cross-bar 29 upon its supporting balls in their cups in base 5.

The lateral control is secured similarly by the elastic pressure of spring 31, which forces plate 20 and the intervening cone 22 horizontally against the side notch of post 24. These springs insure that there will be no backlash in the response of the operating point to the movements of the cones.

The cones are integral with their steel rods and are hardened, ground, and polished to a true form to insure perfectly uniform and steady control. They taper 0.157 inch per inch. The screws have 32 threads to the inch; therefore, one turn of each screw causes a movement of the operating point of 0.155 mm laterally or vertically.

The range of motion of the point in fine adjustment is 6 mm in each of the three dimensions, which gives 3 mm each way from the midpoint at which the controlling screws should be kept. Since the bracket stem and base clamps permit easy and quick adjustment to less than 1 mm, this range is ample.

The use of a setting guide to locate the optical axis of the microscope and the height of the cover-glass of the moist chamber makes a preliminary setting of the point very accurate and simple.

The flexible connections between the screws and the cone rods are necessary, since the rods vary their alignment to the screws and thus would bind or be thrown out of their notches if made integral. They are used between the handles and screws to avoid adventitious movement of the whole apparatus when the handles are actuated. By their use, the apparatus can be made much lighter and less cumbersome without sacrificing essential rigidity.

To coordinate the handle motions with those of the apparent operating point, the right manipulator has all the adjusting screws—14, 16, 25 and 26—with left-hand threads. As a result, when the upper surfaces of the controlling handles are rotated away from the operator (given a right turn), 28 moves the apparent point away, 12 moves it to the left, and 27 lowers it. In the left instrument, on the contrary, to produce the same results only the differential screws of the thrust have left threads, the others having right.

The two instruments are arranged in bilateral symmetry: both have the lateral control on the near side of the thrust, the vertical control on the far side. The rotations of the corresponding controlling handles are, moreover, identical to produce the same direction of movement of the two operating points.

The selection of the proper handles and the conscious coordination of their movements to the corresponding movements of the apparent operating point or points is thus made so essentially simple, even in the double manipulator, as to become quickly automatic. This ease of use is increased by the open construction of the mechanism, its simplicity of design, and its directness of action. That any one familiar with a microscope can understand and use the instrument at once, has been thoroughly demonstrated.

The manipulator is designed to receive a special micro-injector-aspirator in a position permitting its operating handle to be included in the group of manipulator controls (Fig. 1). Convenience and rapidity of operation are thus insured to this line of work. A detailed description of this injector will be given later.

The combined manipulator and injector may be inclined by means of a hinged bracket support in place of the right-angled one shown in Fig. 1, so as to reach into a cavity for operation *in situ* in animals.

The manipulator is designed to operate either under or over a cover-glass and from either the side, front or rear of the optical axis of the microscope. For convenience, in the front and rear approaches, the shaft of the removable operating point unit is bent at right angles, thus permitting the two points of the double instrument to enter one opening of a moist chamber. The front approach is shown in Fig. 1. It is obvious that there are no changes in the relations of the controls.

By means of an attachment not shown in the figures, it is a simple matter to return the operating point to its former position in the field after sliding it away for the placing of the moist chamber, etc. By using both the point setter and the position duplicator, one can fix the point in the optical axis at the proper height, set the duplicator, slide the manipulator away, adjust the moist chamber into its position, slide the manipulator back and find the point in the optical axis ready for work. With a little additional care it is also possible to change points with the same result.

From the above description it will be seen that the new micro-manipulator is presented as a universal instrument, adapted to micro-operation in its widest range. It is believed by its designer and by its sponsors, the Bausch and Lomb Optical Company, to have met the laboratory requirements as above outlined.

G. W. FITZ

PECONIC, L. I., N. Y.

SPECIAL ARTICLES

OVULATION, OESTRUS AND COPULATION WITH CONSEQUENT DYSTOCIA DURING PREGNANCY, IN THE MOUSE

As has been pointed out recently by Swezy and Evans[1] two cases of copulation during pregnancy were observed by Long and Evans[2] in the course of their observations on the rat. Nelson[3] also reported a case of oestrus in the rat, occurring at regular intervals during pregnancy, with copulation taking place at three of these intervals. Swezy and Evans report that the cycle of ovogenesis is not interrupted during pregnancy in the rat, for they observed the periodic appearance of mature follicles and young corpora lutea in the ovary throughout gestation, although they were not able to demonstrate the presence of ova in the oviducts.

I have recently noted a case in which ovulation occurred during pregnancy in the mouse, and furthermore, as in the case reported by Nelson, copulation occurred as was evidenced by the presence of a vaginal plug. During routine examination this mouse which was in labor was observed to be in distress. Examination showed the presence of a vaginal plug which was so firmly attached that it could not be removed by means of a forceps. The animal was observed at intervals from 8: 30 A. M. until 11: 00 A. M. Frequent strong muscular contractions occurred, after which she made attempts to deliver the young. She was left alone, and at 3: 45 P. M. observations were again continued. At this time she was still in labor, but three young had been born. The vaginal plug was found adherent to the vulva and apparently had been forced out by the muscular contractions on the first young to be born. The placenta was attached to one of the dead newborn young, suggesting that the mother probably was too fatigued to dispose of it properly. Since vigorous, periodic labor contractions were still occurring frequently with no results, the animal was killed at 4: 30 P. M., or eight hours after she was first noticed to be in labor. Six fetuses, two of which were alive, were found in the uterus. No movements were observed in the other four, which were still in loco.

Histological examination of the ovaries and oviducts showed that ovulation had occurred. One ovary contained eight young corpora lutea which were about seven hours old, according to Allen's[4] criteria for the age of corpora lutea. The distal portion of the corresponding oviduct contained eight ova. The other ovary contained three seven-hour corpora lutea, and three ova were found in the oviduct. Ovulation evidently had occurred synchronously, because the ova were clumped together and were surrounded by discus cells. Fertilization had not yet taken place, for all but two ova contained the second maturation spindle. These two appeared to be in the prophase of the second maturation division. Twenty-one mature follicles were found in one ovary and sixteen in the other, an unusually large number.

The mouse, a virgin, had been put with a male on May 14. Neither a vaginal plug nor the placental sign had been observed. Twenty-two days later a vaginal plug was found, although pregnancy had not terminated. Presumably the gestational period was of normal length, since the litter did not appear more mature than usual.

It is apparent from these things that not only did ovulation occur during pregnancy but that it was accompanied by oestrus and copulation, the influence of the corpora lutea of pregnancy being insufficient to suppress ovulation until after parturition, as is usual. The number of mature follicles in the ovary suggests the possibility of hyperactivity of the hypophysis, with consequent formation of more than the usual number of follicles, which in turn might secrete sufficient folliculin to cause oestrus to be superimposed upon pregnancy.

This case, together with that of Nelson and the observations of Swezy and Evans, suggests that superfetation may occur during pregnancy in the mouse and hence also in allied forms, provided that ovulation takes place either before the closing of the uterine lumen due to the gestational changes, or after reestablishment of the lumen, before the advent of parturition. If it occurred in the first instance, the difference in the age of the fetuses in the same litter

[1] O. Swezy and H. M. Evans, "Ovarian Changes during Pregnancy in the Rat," SCIENCE, 71 (1828): 46, January 10, 1930.

[2] J. A. Long and H. M. Evans, "The Oestrus Cycle in the Rat and its Associated Phenomena," *Memoirs of the University of California*, 6, 1922.

[3] W. O. Nelson, "Oestrus during Pregnancy," SCIENCE, 70 (1819): 453, November 8, 1929.

[4] E. Allen, "Oestrus Cycle in the Mouse," *Am. J. Anat.*, 30, 1922.